THE EXPLOSIVES ENGINEER

Forerunner of Progress in Mining, Quarrying, Construction

CONTENTS

JOHN J. FORBES—*a photograph* 36

JOHN J. FORBES—*a biography* 37

Editorial 38

The Leadville Drainage Tunnel in Colorado 39
By EDWARD MATSEN AND M. H. SALSBURY

Jumbo Drilling in Missouri Lead Mines 46
By L. W. CASTEEL

The Columbia Basin Project 52
By CHARLES F. THOMAS

Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher

The Leadville mining district in Lake County, Colorado, is famous for its production of rich ores of lead, zinc, silver, gold, and manganese. Total production from the district has already exceeded $500,000,000.

Most of the ore deposits have been mined through shafts, and the presence of large bodies of water involved a continuous and costly struggle to maintain drainage by pumping. When depressed metal prices or work stoppages occurred to curtail operations, the mines became flooded. In 1933, all mining in the district was discontinued, except in the area drained by the Yak Tunnel.

During World War II, metal shortages induced intensive exploration of all domestic resources. The War Production Board designated the Leadville district as a reserve that could contribute needed lead, zinc, and manganese, if the mines in that area were unwatered and rehabilitated. To effect this, the driving of a drainage tunnel 2½ miles long in a southeasterly direction was decided upon.

Work on the tunnel was started in December, 1943, under the supervision of the U. S. Bureau of Mines. Unforeseen ground conditions raised costs so high that funds were exhausted and work was stopped in August, 1945. When, in 1950, a shortage of metals again posed a serious problem, work on the continuation of the tunnel was begun.

The extremely difficult circumstances encountered in driving this drainage tunnel and how these difficulties were overcome are related in the article beginning on page 39.

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St. Joseph Lead Company's operating personnel has been experimenting with jumbo drilling in its southeast Missouri mines for more than twenty years. The early models, built on tracks, were limited as to maneuverability and effectiveness. In 1946, tests of trackless jumbos were begun and, five years later, a combination jumbo and drill was developed, which has resulted in a 13.8 per cent increase in tons produced per driller shift.

Because of the irregular route of the ore pockets, selective mining is imperative. The room-and-pillar method is employed. Because of the variation in sizes and shapes of the ore pockets, it is impossible to lay out a pattern for the headings in advance. The rock in which the lead occurs is a dolomite that drills easily but is difficult to break satisfactorily. For this reason, extra care must be given to the accurate placing of drill holes and the firing of the dynamite charges in proper rotation.

A description of the development of the operating cycle in St. Joseph Lead Company's mines in Missouri will be found in the article beginning on page 46.

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For more than fifty years, the Big Bend country in Washington, embracing an area of more than 150 square miles in the southeastern quarter of the state, has been a land of hopes and heartbreaks. The infrequent streams, or water left in potholes after spring runoffs, were often fouled with alkali. Trees have been scarce and the annual rainfall averages from 6 to 9 in.

Today the scene is changed. Water is coming this year to the land in the Big Bend country because of the Columbia Basin Project, the greatest reclamation program ever undertaken in the United States.

The overall program, now being pushed to completion by the Bureau of Reclamation, dwarfs imagination. For years it has been overshadowed by the immensity of the Grand Coulee Dam, across the Columbia River. Despite the importance of the dam, it is only one unit in a long list of other great feats of engineering and construction.

Please turn to page 52.

EDITORIAL STAFF: JOSEPH I. HORTY, *Managing Editor;* ELIZABETH M. JOYCE, *Assistant Editor;* GERTRUDE A. DONNELLY, *Assistant Editor;* EDWARD L. GRANT, *Art Editor;* FRANK J. CANOVA, *Production Manager;* CHARLES E. RABENOLD, *Advertising Manager;* THEODORE MARVIN, *Director;* MONTGOMERY R. BUDD, *Associate Director.*

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VOL. 30 NO. 2 MARCH-APRIL, 1952

LE ROI

TRACTAIR

LE ROI GIVES YOU MORE FOR YOUR MONEY

Hydraulically-operated Back Hoe — Tractor-compressor-back hoe combination offers big savings on digging jobs too small for power shovels, too big to be done economically by hand labor. Bucket sizes, 12" to 22". Digging depth, 6' to 7'. Swing, 60° each side of center.

Le Roi-CLEVELAND Patcher mounts on rear platform of Tractair. Drills closely-spaced holes within 7-foot radius, then broaches the section of pavement loose for easy removal. On this job, the bricks were removed first to get to the pavement underneath.

Pavement Breaking — Tractair puts air power to work running Le Roi-CLEVELAND Breakers. When the breaking job is done, Tractair maps up with its front-end loader. Tractair can be used also to run Le Roi-CLEVELAND sinker drills, clay spades, backfill tampers.

with Mobildrill

on railroad siding job gives more than twice former footage for less than half equipment cost

As much as 750 feet of hole daily, where only 300 feet were drilled before! More than double the production of three hand-held sinkers and a 315 cfm compressor! Substantial savings on both fuel and equipment costs! That's the remarkable record of a Le Roi Tractair Mobildrill on the Coal River Mining Company's development of a railroad siding at their strip mine in Nellis, West Virginia.

Tractair Mobildrill is a light-weight Le Roi-CLEVELAND wagon drill unit mounted on Tractair — a combination 35-hp tractor and 105-cfm compressor. One man can drive the Tractair Mobildrill and handle every phase of drilling — vertical and horizontal holes at any angle and any elevation up to 12'. Swinging boom permits drilling 4-6 holes of a pattern from one spot.

The Mobildrill attachment is just one example of how Tractair's versatility pays off in lower costs and minimum investment in special equipment. The usefulness of Tractair can be multiplied by using Le Roi-CLEVELAND air tools for breaking pavement, clay digging, tamping fill. Tractair also can be used for loading, lifting, backfilling, snow-plowing, etc., when equipped with a front-end loader and special attachments.

Prove this to yourself. Watch a Tractair at work. Make arrangements with your nearby Le Roi distributor. Write today for job-data sheets and bulletins on Tractair.

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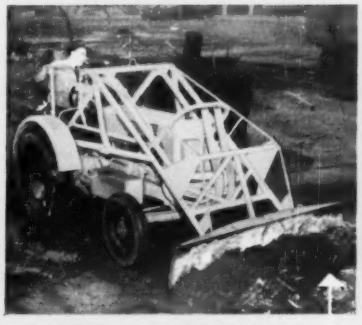
T-20

MORE UTILITY! MORE PROFIT!

Loading — Front-end loader can be attached to Tractair in only a few minutes. Boom combines bucket and crane. Crane folds back out of way when not in use. Bucket holds 10½ cu. ft. — lifting capacity is 1000 lbs. Lifting capacity of crane is 800 lbs.



Backfilling — Replacing the bucket on the loader with a backfill blade adds to the variety of jobs a Tractair can handle. Backfill blade is 6' wide, mold board is 2'8" high. Maximum lift above ground is 1'4".

Trac-Jac — A Le Roi-CLEVELAND air-feed sinker drill mounted on a Tractair. Feeding and drilling controls are within easy reach of operator. The mobility of this unit makes it ideal for mud-jacking and many other applications.

John J. Forbes

DIRECTOR, BUREAU OF MINES
U. S. DEPARTMENT OF THE INTERIOR

A Biography

IN ANNOUNCING the appointment of John J. Forbes as director of the Bureau of Mines, U. S. Department of the Interior, on November 10, 1951, President Truman commented that Mr. Forbes "is one of the world's foremost safety experts and an outstanding career employe in the Government Civil Service."

Jack, as he is known to his associates and friends, was born in Shamokin, Northumberland County, Pennsylvania, November 21, 1885, the son of John P. and Bridget (Buggy) Forbes. After finishing the grammar grades at St. Edward's Parochial School and two years of high school in Coal Township, Northumberland County, he obtained a teacher's certificate at Keystone State Normal School in Kutztown. He taught in the public schools of Coal Township during the next two years, after which he enrolled at Pennsylvania State College, graduating in 1911 with a B.S. in mining.

At the age of ten, Jack worked during summer vacation months as a breaker boy in an underground anthracite mine. Throughout his school years, he continued working in the summer months in the local mines as a laborer, miner, and engineer.

Following his graduation from Penn State, he returned to coal mining, working in several Pennsylvania and Ohio underground properties as foreman miner, junior mining engineer, senior mining engineer, and principal mining engineer. In February, 1915, Jack began his long and eventful association with the U. S. Bureau of Mines as a first-aid miner. Twelve years later, he was made supervising engineer of the Safety Division at Pittsburgh. In September, 1941, he was promoted to the job of chief mining inspector, under the newly authorized Coal Mine Inspection and Investigation Act of May 7, 1941.

With the creation of the Mineral Production Security Division in the Bureau, Jack was transferred to Washington to direct its operations. His responsibilities included the supervision of coal, metal, and nonmetallic mineral mining installations, smelting and metallurgical plants, and quarries. During two work stoppages in the anthracite region in 1943 and 1945, he was appointed anthracite regional manager for the Solid Fuels Administration, operating out of Wilkes-Barre, to insure uninterrupted production of coal during the war years. Upon the completion of these assignments in May, 1948, he returned to the Bureau's headquarters in Washington to become chief of its Health and Safety branch. On November 10, 1951, President Truman appointed him the director of the Bureau. The appointment was confirmed by the U. S. Senate on February 20, 1952.

In supervising health and safety activities, Mr. Forbes visited the principal coal, metal, and nonmetallic mines in the country. Under his direction, more than 1,000,000 men in the mining industry have received instructions in first aid, and approximately 50,000 of these miners have been trained in mine-rescue work. He is the author or co-author of many Bureau publications on mine health and safety and has contributed numerous articles on related subjects to technical magazines and trade journals.

Mr. Forbes is president of the Joseph A. Holmes Safety Society; chairman of the training and education division, Federal Safety Council; program chairman, coal mining section, National Safety Council; a past president and a member of the Coal Mining Institute of America, Pittsburgh Coal Mining Institute, West Virginia Coal Mining Institute, National Mine Rescue Association, and of Mine Rescue Veterans of the Pittsburgh District; past chairman and a member of Washington Safety Society; and a member of Mine Inspectors Institute of America, and Monongahela Valley Mining Institute.

John J. Forbes married Irene L. Mudd on March 26, 1917, in Pittsburg, Kansas. They have two children: Mrs. Marisse L. West of Pittsburgh, Pennsylvania, and John W. Forbes of Chevy Chase, Maryland. The family home is located at 4301 Massachusetts Avenue, N.W., Washington, D. C.

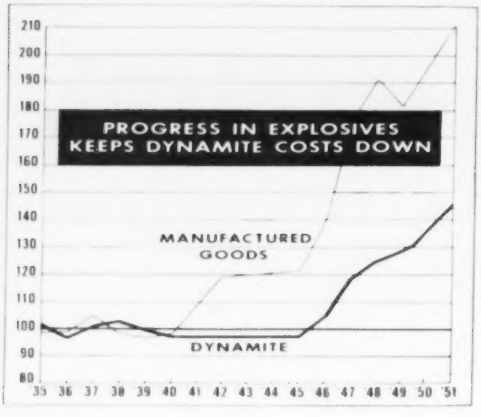
JOHN J. FORBES

Editorial

A Look at Dynamite Prices

We have commented before in these columns that increasing the efficiency of dynamite usually does not change its appearance—it looks much the same today as it did forty years ago. That's why many people are not aware of the improvements that have been made in today's product.

Progress in the manufacture of dynamite is obvious mainly to researchers who devise improvements and demonstrate their value by exhaustive tests, and to users who record the performances and costs of dynamite over a number of years. Millions of dollars and untold hours of intensive scientific effort have brought modern fixed explosives to their present effectiveness and economy. At the same time, explosives makers have succeeded in keeping down their costs. This is reflected in the accompanying chart which shows the relative stability of dynamite prices since 1935, as compared with prices of other manufactured goods. (1935-1939 values represent 100.)



Customers of the explosives industry can be assured that manufacturers in the United States will continue to devote their resources constantly to the improvement of dynamite and to its sale to users at prices consistently lower than other manufactured goods.

The 1952 Coal Convention

The 1952 Coal Convention of the American Mining Congress will be held May 5 through 7, at the Netherland Plaza Hotel, Cincinnati, Ohio. The program includes a series of general meetings for the presentation of papers and reports of particular importance to deep- and strip-mining operators by men prominently identified with industry and government. Specialized group forums will be provided for the examination and discussion of improved practices with traditional equipment as well as the application of new types in the experimental stage.

Coal men have been given a goal—600,000,000 tons in 1952, and 1,000,000,000 tons in 1975—and the knowledge gained at the 1952 meeting in Cincinnati will go a long way in helping the industry attain its goal.

Those planning to attend are urgently advised to make applications for room reservations without delay. A record attendance is anticipated.

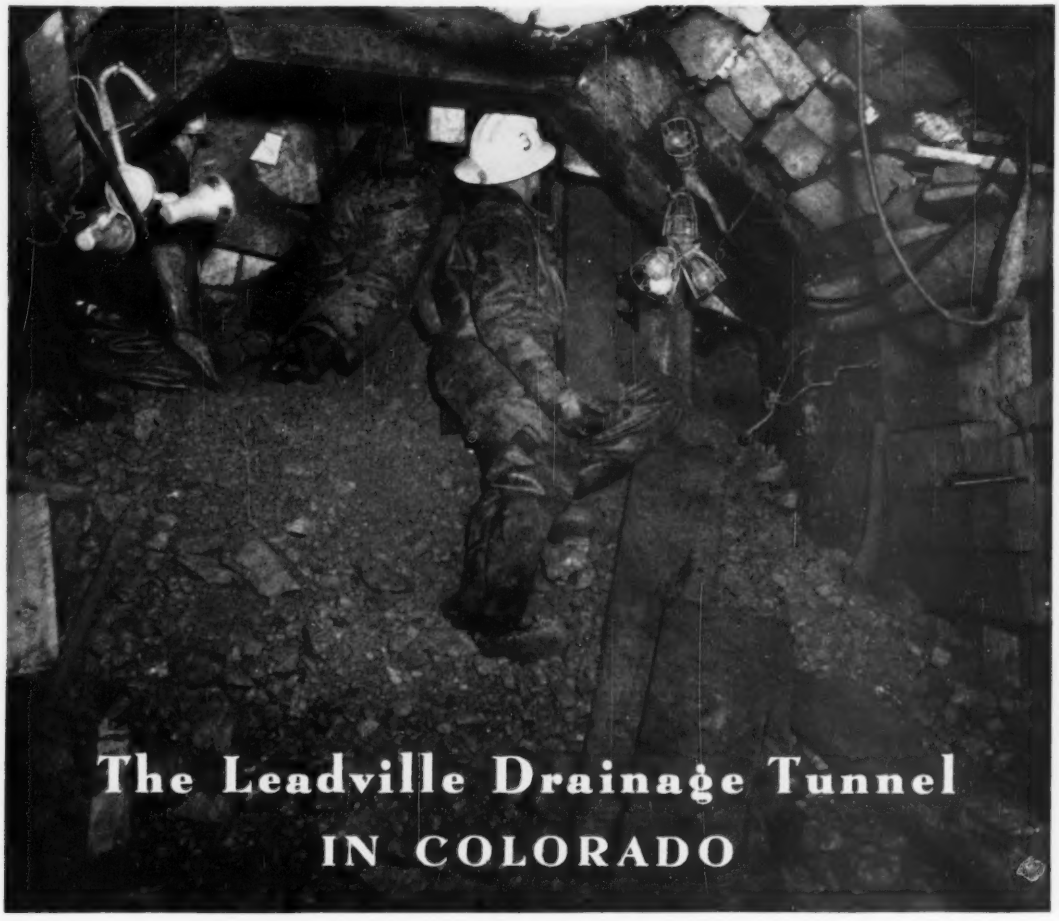
Blasting Caps and Children

Vacation time is just around the corner. To thousands of school children the summer months are a time for exploring the great outdoors. It is also a time when highway and building construction jobs reach the peak of their activities. It is natural for vacationing school children to be interested in all kinds of construction work. For that reason, everyone who handles, stores, and uses industrial explosives on such projects is obligated to see to it that extreme care is exercised in preventing blasting caps from getting into the hands of our boys and girls.

The Institute of Makers of Explosives wages a never-ending campaign to warn the public, particularly boys and girls of school age, of the dangers hidden in the apparently harmless little blasting caps. Posters, display boards, and prints of a sound-motion picture are available at the office of the Institute, 343 Lexington Avenue, New York 16, New York. The 15-minute movie, with the title "Blasting Cap," shows full-color scenes of industrial explosives in action in mines, quarries, on construction jobs, and farms. The story builds up to a dramatic climax, which leaves a vivid, lasting impression on all who view it of the dangers of playing with blasting caps.

Despite the constant activity in carrying warnings to the children and parents, and the decrease in the number of accidents from blasting caps each year, the situation is still far from bright. The Bethlehem, Pennsylvania, *Globe-Times* newspaper lends emphasis to this fact in an editorial published February 13, 1952. The editorial said, in part, that "every Bethlehem parent must have shuddered last night after the disclosure in the *Globe-Times* that scores of West Side schoolboys have been playing with and exploding dynamite (blasting) caps. Only good fortune prevented the maiming or killing of one or more boys. By the narrowest of margins, Bethlehem has escaped a tragic disaster."

Two comments are in order on the *Globe-Times* crusade for more vigilance in the handling and storing of blasting caps. First, the near disaster in Bethlehem occurred in the middle of winter months, not during vacation time. Second, what is true in Bethlehem is true anywhere in the world where, through negligence and carelessness, blasting caps can get into the hands of boys and girls.



The Leadville Drainage Tunnel IN COLORADO

The driving of more than two miles of tunnel under extremely difficult circumstances has unwatered abandoned and flooded mines

EDWARD MATSEN and M. H. SALSBURY*

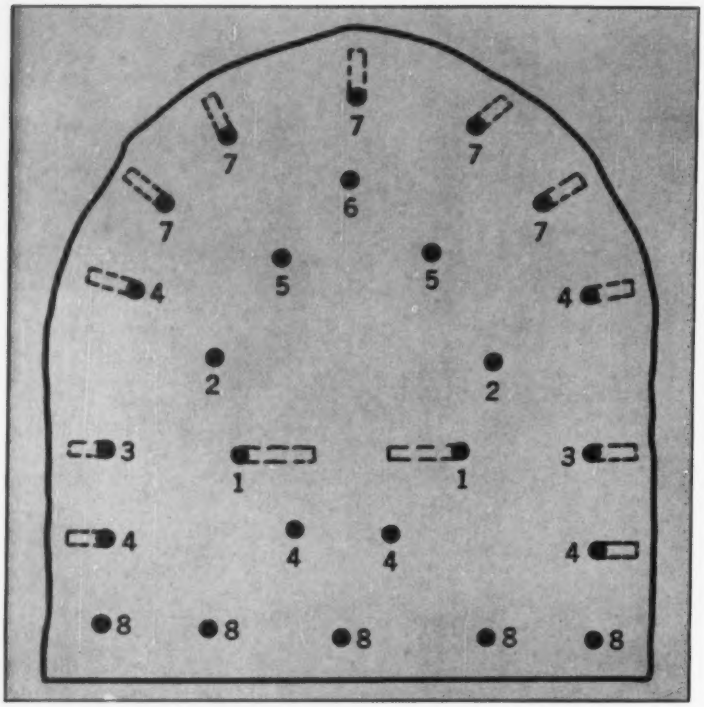
LEADVILLE, the scene of much of Colorado's mining history, started as a gold camp in 1861. Placer deposits were found in California Gulch by prospectors working up the Arkansas River tributaries. The placers were worked for many years but were of limited extent. The production of placer gold gradually declined, but the discovery of a few gold-bearing lodes maintained the dwindling production of the district from 1868 through 1871.

In 1874, two California Gulch placer operators became curious about the "heavy sand" that had always been a nuisance in the sluice boxes. An assay revealed that the sand contained lead and silver ore, identified as a silver-bearing lead carbonate. A search soon revealed outcrops of lead carbonate ore on the slopes of California Gulch. Leadville's importance as a lead producer dates from this discovery. Later, the lead ore was found to occur much more frequently. Also, further gold discoveries proved to be much richer than the original discovery lodes.

To date, the total production from the Leadville district, consisting of lead, silver, gold, and, in later years, zinc and manganese, has exceeded $500,000,000. Although production has fluctuated, Leadville has survived three major depressions and is now entering a period of increased production under the stimulus of the current demand for lead and zinc.

*Mining Engineers, Bureau of Mines
U. S. Department of the Interior

EMERGENCY TIMBERING: Miners rushed special timbers into place at a tunnel heading 1½ miles from the portal, to support the crushing weight and to stem the flow of broken rock and sand that poured in through every crack in the severely fractured quartzite.



TUNNEL ROUND. This diagram shows the location of drill holes in an average round in the Leadville Tunnel, as used in November, 1951. Two or three additional holes were included when circumstances warranted. The numbers indicate the sequence of firing a blast.

MECHANICAL LOADER. Following a blast, an Eimco No. 21 RockerShovel is being moved up to an underground working place. Steel sets and close timber lagging had to be installed in the tunnel to support the bad ground through which the bore was driven.

Ground Water Hampered Mining Ventures

Since the first days of underground operations, Leadville mining ventures have been hampered by ground water. Often, bailing or pumping had to be employed at a very shallow depth. As greater depth was reached and more territory opened up, water flows increased, frequently limiting the extent of operations.

For this reason, the thoughts of Leadville miners soon turned to the need for drainage tunnels. A number were proposed. The first of any consequence was the Yak Tunnel, started in 1895 from a portal in California Gulch at an elevation of 10,300 ft. This was so successful as a drainage, exploration, and transportation tunnel for the mines of Iron Hill that it was later extended to a total of 4 miles and is now used by Resurrection Mining Co.

In 1922, the Canterbury Tunnel, a community project, was driven 4,000 ft. to drain and explore the area north of the known productive area. The tunnel developed substantial water flow, but ore discoveries were disappointing.

In 1934, a 39,400-ft. tunnel at an elevation of 9,600 ft. from a site on the Arkansas River west of Leadville was proposed as a WPA project, but the proposal was rejected. Subsequently, in 1934, the Resurrection Mining Co. considered a tunnel under Fryer Hill, but the work was not undertaken.

After World War II started, shortages of metals, resulting from greatly increased consumption, induced a search for new supplies. A survey of possible reserves by the War Production Board designated Leadville as a promising area for new reserves of lead, zinc, and manganese. A study of the time required to make the deposits productive by unwatering the mines showed that a drainage tunnel was preferable to pumping and would have more lasting benefits. It appeared that the work could be completed in time to be of value in the war effort.

Portal Site Chosen

Accordingly, in November, 1943, after consideration of several locations, a portal site was chosen on the east fork of the Arkansas River at an elevation of 9,960 ft. It was proposed to

drive the tunnel 2½ miles southeasterly to drain all or most of the Fryer Hill, Carbonate Hill, and Iron Hill basins to the level of the tunnel. It was believed that, with modern tunnel-driving methods, the work could be completed rapidly.

Although many mines already were deeper than the tunnel, a site at a lower elevation was out of the question because of the time factor. The tunnel as planned would lower considerably the pumping cost of mines that might be worked below the tunnel level.

In December, 1943, the Congress appropriated $1,400,000 to enable the Bureau of Mines to construct the proposed tunnel. Right-of-way was obtained, and work was started immediately under the supervision of the Bureau. A cost-plus-fixed-fee contract to drive the tunnel was awarded Stiers Bros. Construction Co. of St. Louis, Missouri.

Unforeseen ground conditions in the first 2,500 ft. raised the cost of tunneling so much that the appropriation was exhausted after 6,600 ft. of tunnel were driven. Work was stopped in August, 1945, as the immediate demand for metals declined with the end of the war.

When the shortage of lead, zinc, and manganese again became serious in 1950, a new appropriation was included in the regular Department of Interior budget, and work on the continuation of the tunnel, under supervision of the Bureau of Mines, was begun again in September, 1950.

Tunnel-Driving Methods

The Leadville Drainage Tunnel as begun was 10 ft. wide and 11 ft. 6 in. high in the clear. After 335 ft. of driving in unconsolidated material, the size was reduced to 9 ft. wide by 10 ft. 6 in. high in the clear. This size was maintained to 6,600 ft. from the portal, at which point work under the first contract with Stiers was suspended.

Work was resumed in September, 1950, under a contract awarded to the Utah Construction Co. The tunnel was redesigned and a cross section 7 ft. 6 in. wide and 8 ft. 9 in. high in the clear was adopted. This size was maintained to a point near the Robert Emmet shaft, 9,917 ft. from the portal.

The smaller tunnel offers several

SEVERE WATER CONDITIONS: Water from the Empire Zinc Company's flooded Robert Emmett shaft rushes through a drill hole at a working place into the Leadville Tunnel. At right, Harry Greshuk, project manager for Utah Construction Co., investigates the situation.

TUNNEL PORTAL: A view of the portal of the tunnel being driven to unwater abandoned and flooded mine workings in Colorado's famous Lake County lead and zinc district. The drainage ditch in the foreground is carrying off 3,600 gallons of water a minute.

UNDERGROUND JUNCTION. The Leadville Drainage Tunnel and the 190-ft. lateral tunnel, which extends to the Hayden shaft, come together at this junction. The pipes overhead carry air for ventilation and compressed air for the operation of equipment.

advantages. The smaller size is easier to support in bad ground, less material is needed for tunnel support, less muck has to be hauled from face to dump, and drilling time and powder consumption are reduced.

However, the more crowded working condition at the face, particularly with the standard-size tunneling equipment which the contractor furnished, was a disadvantage. Consequently, in the summer of 1951, when new steel and timber supports were ordered, a clearance of 8 ft. wide and 9 ft. high was decided upon, and the tunnel beyond 9,917 ft. is being driven to the new dimensions. The heading as of January 23, 1952, was 11,040 ft. from the portal.

The original ditches in the tunnel were formed by raising the track, placing 6 by 6-in. longitudinal stringers under the ties, and ballasting between the ties and stringers, confining the rock with 1-in. boards nailed to the ends of the ties. Beyond 6,600 ft. this method did not allow enough ditch capacity with the smaller tunnel size. The ditch is now formed by raising the track on transverse 6 by 6-in. stringers at 5-ft. intervals blocked up to grade at each end. Two 6 by 6-in. ties are placed between stringers, both being supported in the center by longitudinal blocking. No ballast is used. This method forms a ditch 18 in. deep the full width of the tunnel, which, while it is partly obstructed by the track support, is the maximum obtainable in a tunnel of this size.

Drilling

At the beginning of the present contract, a drill carriage built in the Utah Construction Co. shops was furnished. This carriage was the usual type, with superstructure designed for the short columns and crossbars used in many present-day tunneling operations, which mounts four or five drills. After a few weeks of trial, this carriage proved too large and cumbersome for a small tunnel. It was cut down, all superstructure was removed, and three LeRoi - Cleveland air-operated jibs were installed in place of columns and crossbars. Each jib mounts a Gardner-Denver CFS9H 3½-in. drifter with 30-in. automatic feed and sliding-cone, aluminum-alloy shells. The rebuilt drill carriage proved very satisfactory and is now in use.

The rock formations in the tunnel vary from a hard, brittle quartzite through moderately hard limestone, soft sandstone, shale, and soft, highly altered porphyritic intrusives. In faulted sections, the quartzite is often crushed to a sand which, when encountered with a heavy water flow, forms running ground. The hard quartzite is quite abrasive, and bit-wear in this rock is severe. In other formations bit-wear is slight.

Round-lugged 1¼-in. drill rods in 3-, 5-, and 7-ft. lengths and I-R Jackbits are used in normal drilling. Gardner-Denver sectional drill rods and I-R inserted tungsten carbide bits are used in long holes up to 50 ft. deep, which are drilled occasionally to probe the ground ahead of the face. A typical drilling pattern in the solid rock consists of 23 to 28 holes depending on the nature of the ground. (See sketch.)

Blasting

Blasting is done electrically with a semi-gelatin grade of dynamite of approximately 46% strength and No. 6 Electric Blasting Caps with 8 to 10 delay periods. In solid rock, 30 to 80 lbs. of dynamite are used per round, with the average not over 40 lbs. The spacing and pointing of drill holes are not critical and are varied to fit the ground conditions encountered; no difficulty is experienced in "pulling" the ground. Care must be exercised only to avoid excessive overbreak.

A normal round, drilled 5 ft. deep with 6-ft. cuts, is used and usually pulls the full depth of the holes. The 5-ft. depth was found to fit timbering requirements and the limitations imposed by haulage capacity.

The rounds are blasted according to the condition of the face. In highly fractured ground—usually crushed quartzite with heavy water flow—only the cut holes may be fired, the balance of the round being blasted as conditions dictate. In less extreme conditions the back holes may be left for

subsequent blasting if more clearance for timber is needed. Often, particularly in blocky porphyry, these holes need not be blasted.

Blasting procedure is to connect the electric primers in parallel to the lead wires and the blasting circuit. The blasting circuit consists of two No. 8 rubber-covered wires carried through porcelain insulators fastened beneath the ventilation pipe. Other electrical circuits are carried on the opposite side of the tunnel. The blasting switch is a minimum of 1,500 ft. from the face and consists of a fused switch in a locked cabinet with an extension cord that must be carried across the tunnel and plugged into another switch. Power is obtained from the lighting circuit and passes through a small 220-volt transformer. The shift boss carries the key to the blasting switch.

Whenever the possibility of encountering increased water flows is indicated or even suspected, pilot holes up to 40 ft. in length are drilled to explore the formation ahead. In the vicinity of flooded mine workings, an extensive pattern of holes is drilled for safety, even though there is no expectation of a direct connection. Normally, a pilot hole 15 to 20 ft. deep is drilled ahead every third round.

Compressed air for the tunnel is supplied by an Ingersoll-Rand, Type XRE, two-stage compressor powered by a 250-hp. synchronous motor. Output of the compressor is 1,750 cu. ft. per minute; discharge pressure is 125 lbs. per sq. in. Air is conveyed to the heading in a 6-in. pipe line.

Loading and Haulage

Haulage equipment consists of two 6-ton Atlas storage-battery locomotives, eight 91-cu. ft. Card Granby-type cars, and four Madsen side-dump cars. This equipment, furnished by the Utah Construction Co., is supplemented by a 7½-ton Jeffrey storage-battery locomotive owned by the Bureau of Mines.

The loading equipment consists of two Eimco No. 21 RockerShovels. A standard round breaks eight to ten cars of muck, which is loaded in 30 to 90 minutes, depending on delays occasioned by the need for placing crowbars or lagging overhead for safety in the blocky ground. If delays arise through the need for safety measures,

AT HAYDEN SHAFT: Edward Matsen, resident engineer for the Bureau of Mines and co-author of this article, at left, and Mitchell Gordon, correspondent for the Wall Street Journal, inspect the once-flooded Hayden shaft.

CHECKING WATER FLOW: M. F. Buckbee of the Bureau of Mines records a measurement of the volume of the flow of water from Leadville's long-flooded mines as it rushes through a weir after leaving the drainage tunnel.

SURFACE PLANT: A view of the surface plant and yard of the Leadville Tunnel, as seen from above the portal. Water from the tunnel drains into the east fork of the Arkansas River which flows through the meadow beyond the shop buildings.

only part of the round is hauled out immediately, otherwise, the entire round is hauled out at once.

Switching is done on a "Canton" portable carpass placed in sidings excavated on the right side of the tunnel at 250- to 350-ft. intervals. In normal procedure, two locomotives are used in loading. The front locomotive handles the loads and shuttles back and forth from the switch, pushing empty cars up to the loader while the rear locomotive feeds empties to the switch. When only one locomotive is available for loading, the empties are carried on the rear of the locomotive and delivered to the switch while the loader is filling the car.

The Eimco loader pulls the car being loaded by means of a coupling when the fly rock is being cleaned up. Usually, however, the coupling is not used, and the car remains hooked to the train after the main muck pile is reached.

The haulage track consists of 52-lb. rails on 24-in. gauge carried on 6 by 6-in. ties on 24-in. centers. Rail sections 6 ft. long, made up with steel ties, are used in the heading, until 30-ft. rail lengths can replace them. In advancing into the muck pile, U-shaped rails are slipped over the regular rails and pushed ahead with the loader bucket as mucking proceeds.

After being hauled to the portal, the muck train is divided, and four cars are taken out at a time for dumping. A roller dumping arm is attached to each car on the dump and serves to tilt and empty the car when the arm passes over the dumping ramp. The emptied muck train is returned to the tunnel immediately to be ready for the next blast.

Tunnel Supports

Several types of tunnel supports are used. In moderately heavy ground, commercially fabricated steel sets, each composed of two heat-treated ribs rolled out of 5- or 6-in. H-beams joined at the crown, are placed at 5-ft. intervals. Six 4 by 6-in. collar braces and six ¾-in. tie rods with necessary 2- or 3-in. lagging are used to secure the sets.

In heavy ground a 10 by 10-in. treated five-piece timber set with a three-segment cap is used. These are also placed on 5-ft. centers and lagged as required. All sets are blocked tight to the ground.

In running ground, timber sets with 4 by 6-in. top and side spiling are used. When there is a heavy water flow, it may also be necessary to breast-board and lace the face of the tunnel. In less extreme cases top spiling only is needed. The spiling is driven by hand or with the Eimco loader when possible.

In ground that is blocky but not heavy, steel sets are used, and 4 by 6-in. lagging is placed overhead as soon as possible after blasting. After the heading is mucked out, the next steel set is placed and blocked to line and grade with 2-in. lagging placed on the sides as required.

Timbering costs have been high throughout the tunnel. Beyond 6,600 ft., 2,765 ft. (64.1 per cent of the 4,318 ft. of tunnel and laterals driven) have been supported. Originally it was estimated that 30 per cent of the tunnel would require support.

Ventilation

Ventilation equipment consists of two Roots-Connorsville positive-pres-

sure blowers with a combined capacity of 7,000 cu. ft. of air per minute, powered by 60- and 70-hp. motors. The blowers are arranged for either blowing or exhausting.

Ventilation pipe is 20-in.-diameter welded pipe carried within 50 to 75 ft. of the heading. Present practice is to provide positive ventilation for all portions of the operating cycle except blasting, when the circulation is reversed and air is exhausted for 20 to 30 minutes. Ventilation of the tunnel with the equipment described is completely adequate. The temperature in the tunnel is never above 45 F., even during the summer months.

Operating Time Cycle

Extremes and average time of the complete cycle in average ground formation, where caving or running ground is not encountered, is shown below:

	Minimum time		*Maximum time*	*Average time*
Drilling	0:45 hr.	to	1:15 hr.	1:00 hr.
Loading and blasting	30		45	40
Ventilation	15		30	20
Mucking and switching	45		1:30	1:00
Timbering	00		2:00	1:30
Laying rail sections	15		30	20
Total	2:30		6:30	4:50

At present the tunnel is being driven by two shifts through a soft, blocky formation at the rate of 15 ft. a day. Three complete cycles are made, and three sets of steel supports are placed.

A normal crew on one shift, furnished by the contractor, is made up of 36 men: heading crew, 11; outside haulage, 3; pipe and track, 9; maintenance and outside details, 9; supervision and office force, 4. The track-and-pipe crew works on the 11 p.m. to 7 a.m. shift while the heading is not operating. They put in permanent track, advance 20-in. ventilation line, 6-in. compressed-air pipe, and 2-in. water supply pipe. They also raise the track to form a drainage ditch and do all the necessary track maintenance throughout the tunnel.

Conclusion

The tunnel has already achieved its objectives in part. Connections have been made with the Hayden shaft in the Fryer Hill area and the Robert Emmet shaft in the Carbonate Hill area. Drainage of the Fryer Hill area near the tunnel has been accomplished, and continued flow into the tunnel indicates that the water level is being lowered some distance from the tunnel. The deeper mines in the Graham Park area, interconnected with the Robert Emmet shaft, are also drained to tunnel level. In shafts where it is possible to measure water levels, including two in the "Downtown Area," a definite lowering of the water level is shown. The drainage effect of the tunnel will continue to spread for some time.

At present the tunnel heading is approaching the New Mikado shaft and a major fault just beyond, which is the immediate objective. It is believed that penetration of this fault will effect drainage of additional water-filled areas.

Although no work beyond the Mikado fault is planned at present, continuation of the tunnel would be of great advantage to the eastern section of the Leadville mining district. Development is being carried on by the American Smelting & Refining Co. to open up recently discovered ore deposits in the down-faulted block between the Weston and Ball Mountain faults. This work is greatly handicapped at present by heavy water flows. The Resurrection Mining Co. is also carrying on operations in this area some 300 ft. below the Yak Tunnel level. Tunnel drainage would make accessible more of this comparatively undeveloped territory, an area which is likely to furnish much of Leadville's future production.

HAYDEN SHAFT: This property at Leadville is being rehabilitated by Caldwell Mining Company, which recently signed a contract with Defense Minerals Exploration Administration. A lateral connects the Leadville Tunnel with this shaft.

Jumbo Drilling
In Missouri Lead Mines

St. Joseph Lead Company's experiments with jumbo drilling have resulted in a 13.8 per cent increase in tons produced per driller shift

L. W. CASTEEL*

ST. JOSEPH LEAD COMPANY'S operating personnel has been experimenting with jumbo drilling in its southeast Missouri mines for more than twenty years. Several types of jumbo drill rigs have been made in the company's shops and experiments have been carried on. Numerous drill rounds have been tried with varying degrees of success. The early jumbo models were built on mine railroad tracks, which limited their maneuverability and effectiveness. In 1946, the testing of trackless models was begun. After five years of experimenting with trackless jumbos, a combination jumbo and drill was produced that has resulted in a 13.8 per cent increase in tons per driller shift.

In the Lead Belt, standard drilling equipment consists of a column-mounted rock drill with a 2⅜-in. bore and a 36-in. pneumatic feed. Holes for blasting are drilled in slab settings with ⅞-in. hexagonal drills and Craig detachable bits. At present, these drills are being used to break about 90 per cent of the rock recovered in the district. The twelve jumbos that are operating break the other 10 per cent. Data obtained during the last six months of 1951 showed that the jumbos broke about 9.3 tons more per driller shift than was realized from the conventional method. This represents a substantial improvement, but it does not equal the sensational results obtained by jumbos in other districts. However, a study of the physical conditions surrounding the operations of St. Joseph Lead Company makes apparent the problems encountered in jumbo drilling in this district.

The ore occurs in pockets very irregular in size and shape and of such low grade that close, selective mining is imperative. The room-and-pillar method of mining is employed. It is impossible to lay out the pattern in advance because the headings must follow the irregular route of the ore.

*Mine Superintendent
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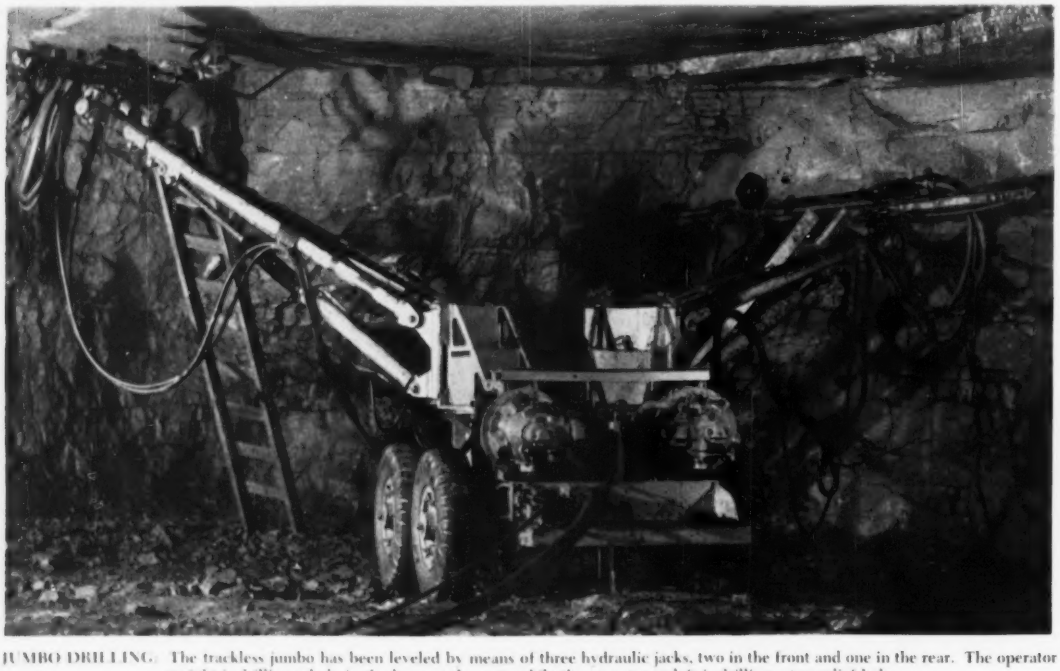


JUMBO DRILLING. The trackless jumbo has been leveled by means of three hydraulic jacks, two in the front and one in the rear. The operator at right is drilling a hole in the burn-wedge cut, while the operator at left is drilling a top relief hole.

SLABBING: The jibs are swung back to line the machines for drilling outside slab holes. If the pillar spacing is 26 ft., two settings are usually sufficient to drill holes on each side of the cut.

In many stopes only one heading can be advanced in ore. Obviously, as soon as one round has been drilled in such a heading, the jumbo must remain idle until the broken ore is loaded out, or the rig must be moved to another stope. The stopes are connected by 9 by 10-ft. haulage drifts, which means that the jumbo must be small in size in order to be moved swiftly without being dismantled.

The pillar spacing varies from 20 to 40 ft., depending on the strength of the roof rock or the width of the ore body. The average height of the operating stopes is 10.5 ft., but this may range from 6 ft. up.

The rock in which the lead occurs is a dolomite that is fairly easy to drill but hard to break. The holes must be accurately placed and fired in the proper rotation or the result from a blast will be a misbreak.

With such radical changes in conditions from one stope to another, flexibility and small size become the prime requisites in the design of any jumbo to be used in this district. A study of jumbos used in other mines made it apparent that a new jumbo would have to be designed to fit the conditions in the Lead Belt.

The First Trackless Jumbo

The first trackless jumbo designed for this district consisted of an R2 Caterpillar chassis powered by a five-cylinder radial air engine. Two tubular 4-in.-diameter telescoping boom arms were fastened to a circular turnplate mounted on and supported by the tractor chassis. The arms were 6 ft. long when closed and 12 ft. when fully extended. They were supported and elevated by a Coffing manually operated hoist. The telescoping arms were extended by air pressure and manually retracted. A horizontal bar 7 ft. long and 2 in. in diameter comprised the crosshead for the boom arms and supported two HC10 Cleveland rock drills with 36-in. pneumatic feeds. This jumbo was used in drilling slab holes in much the same manner as column-mounted drills. However, it was soon determined that further ease and simplification in the alignment and adjustment of the drilling equipment were definitely essential if the jumbo was to be a success.

With this in mind, the existing turnplate with attached boom arms was replaced by two Sullivan DJ-S Hydro Drill Jibs. These offered a sturdy, simplified drill mounting with greatly increased ease of operation. The vertical movement of the jibs was controlled by a manually operated hydraulic pump and the horizontal swing by manual operation, with the desired position being maintained secure by a capstan plate. At the end of the jib, drill alignment in the three geometrical planes was obtained by a combination swing saddle whose movements were secured by three separate chuck nuts.

The HC10 Cleveland drills with 36-in. pneumatic feeds were replaced with T-300 Sullivan 3-in. drifters mounted on 6-ft. Sullivan air-powered chain-driven feeds. These replacements permitted 6-ft. drill changes and an increase in drilling speed because of the larger machines.

These changes were a step in the right direction but considerable difficulty was still encountered in aligning holes in a vertical plane. As the jibs were raised or lowered, the machines attached to the end moved in an arc instead of moving in a straight line. This problem was overcome by redesigning the end of the jib to make it extendible for a distance of 33 in. The new design made it possible for the machine to travel in a straight vertical

line by either extending or retracting the end of the jib as it was being raised or lowered.

At this stage in the development of the jumbo, it became apparent that, while it was a very flexible machine, it was not suitable for slab drilling. It did not give sufficient improvement over the regular column-drill performance to justify the initial expense. All efforts were concentrated on designing a drill-hole pattern, or round, that could be drilled by the jumbo with a minimum of adjustments and one that would break sufficient ore to warrant the use of the jumbo. Several months of experimenting produced many failures. But out of the failures a round emerged that, with a few exceptions, fills all of the requirements.

The Burn-Wedge Cut

The development of a cut that would break in any of the various types of dolomite to be encountered in the district presented the greatest problem. Pyramid-, wedge-, and burn-cuts were all tried but they would not produce consistently satisfactory breakage in all types of rock. The final solution was found to be a combination burn-wedge cut. This cut consists of three horizontal holes on each side drilled parallel and only 6 in. apart. The sides, collared 12 ft. apart, come together on the points a distance of 12 ft. in the rock, thus forming an equilateral triangle 12 ft. on each side and 12 in. thick. This cut opens up a slot that gives the rest of the holes the necessary free faces for the desired breakage. Approximately 3½ ft. above the cut, two more holes are collared 12 ft. apart, coming together on the points. Matching holes are drilled 3½ ft. below the cut. This will carry ground 8 to 10 ft. high. If higher ground is to be carried, an extra set of these holes is drilled above the cut. When fired, the holes break a wedge 10.4 ft. deep from top to bottom, and perpendicular to the face. The remaining holes in the round are arranged in five-hole slab settings on each side, breaking to the cut. The number of slab settings drilled is dependent upon the pillar spacing in the stope. If the pillar spacing is 26 ft., which is about average, two slab settings are drilled on each side of the cut.

In this district, the breaking angle of the rock is about 108 degrees. Through experimentation it was found useless to drill slab holes deeper than this angle. Therefore, the round is drilled to carry the face in a wide angle V-shape, with the center of the V located at the point of the cut holes and the sides sweeping back at an average angle of about 15 degrees. All holes in the round are bottomed with the same length drill. The depth of each hole is adjusted automatically to the breaking angle by the swing of the jibs on the jumbo. This is shown in an accompanying sketch.

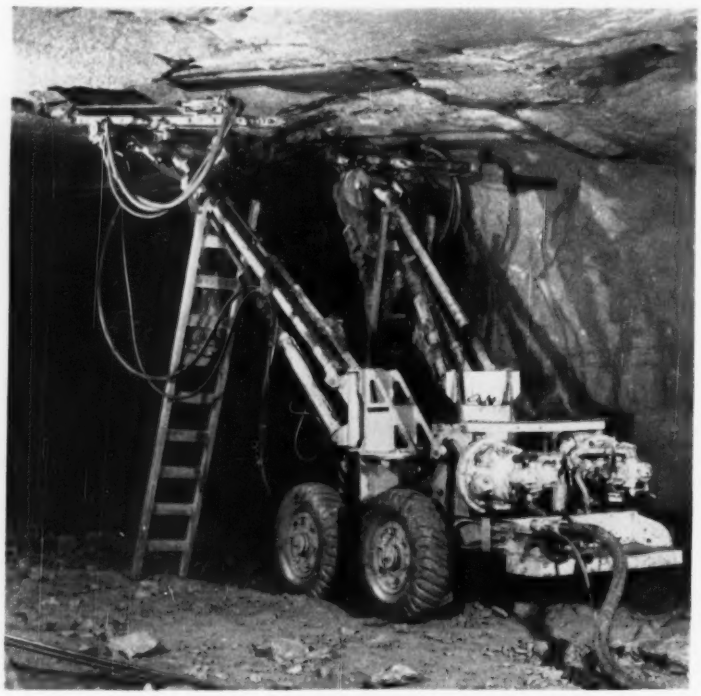
Blasting

The round is loaded with 125 lbs. of 40% semi-gelatin dynamite in 1 by 8-in. cartridges. The powder loading factor is a little high in low ground but is reduced considerably as the height of ground increases. In ground 12 ft. high, 2 tons of rock are broken per pound of explosives used.

The round is fired electrically, using short-period delay electric blasting caps connected in series. Standard delay-period electric blasting caps have been used, but the short-period delay caps give better fragmentation.

There are several definite advantages that result from the use of this round. With 26-ft. pillar spacing it will, with fair consistency, break 20 tons per foot of height. It can be drilled from one setup of the jumbo with a minimum of adjustments to the jibs and the machines. In one shift, two men can drill and blast one complete round of holes, including a reasonable amount of time allowed for unforeseen delays. A short period of instruction is all that is required to teach a crew how to drill the round. The settings of the different adjustments on the jumbo are marked and the alignment of the drill holes becomes almost automatic. The rock broken by the round is brought down in a pile that is ideal for loading operations, with very little fly rock.

The development of this drill round definitely advanced jumbo drilling out of the experimental stage into a full-fledged production unit. However, the



IN THE ROOF: The jibs can be raised to drill a level hole in the roof at a height of 15 ft. If a face higher than 15 ft. is carried, the top drill holes are pitched upward.

ON THE MOVE: The jumbo travels under its own power with four-wheel chain drive. Tramming speed is 58 ft. a minute. It can be converted easily to free-wheeling for towing to distant headings in the mines.

jumbo required further refinement to simplify the drilling of the round. Accurate hole alignment was necessary to obtain success with the new round. With the jumbo in use at that time, proper hole alignment was a time-consuming process. Various improvements were tried and added. Finally, in conjunction with the Joy Manufacturing Company representatives, the St. Joseph Lead Company engineers designed and had built the Joy Drillmobile, the jumbo now in use by the company in the district.

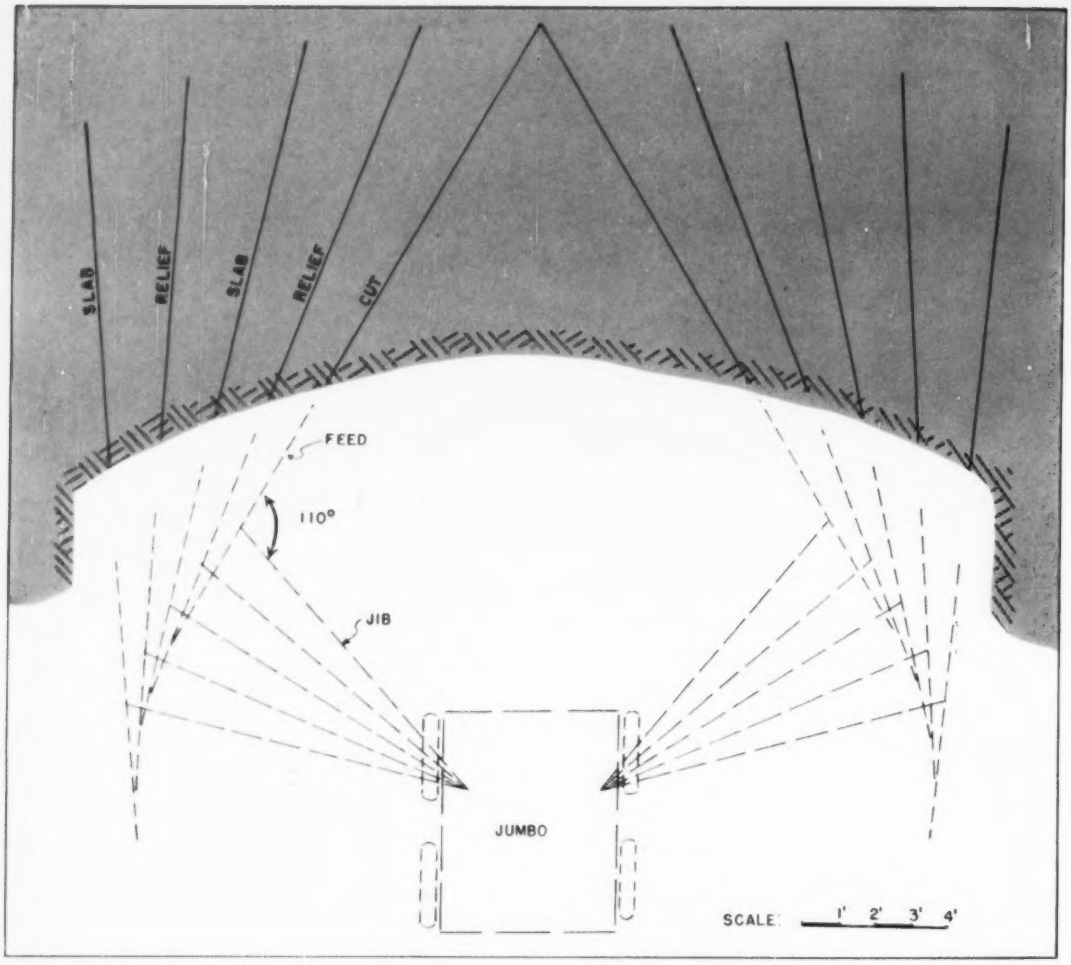
The Joy Drillmobile

The Joy Drillmobile consists of a rigid steel frame mounted on four 7:00 by 15, 12-ply, hard-rock lug tires. Its general dimensions are: wheel base, 42 in.; overall length with jibs, 156 in.; overall width, 71 in.; overall height with jibs, 57 in.; approximate weight, 7,200 lbs. Power for tramming is obtained from two Model PA-95, five-cylinder pistonair motors each with a BHP rating of 6.6 at 80-lb. pressure. The motors are mounted horizontally 12 in. on either side of the center line of the chassis. They are operated independently of each other and are flange-mounted to a worm gear-and-sprocket assembly, driving an endless heavy-duty chain which runs over sprockets mounted on both the front and rear axles, offering four-wheel drive. Tramming speed is 58 ft. a minute. By removing a cap screw and bushing, the unit can easily be converted to free-wheeling for towing to distant headings in the mines.

The Drillmobile is equipped with two DJA Hydro Drill Jibs which are 10 ft. long from the center line of the saddle support to the center line of the pivot point at the base of the jib. An extension on the jibs consists of a rack and pinion actuated by hand. This feature gives the jibs an extra length of 33 in. and is especially useful in the alignment of holes in a vertical plane. Vertical and lateral movements of the jibs are obtained completely by hydraulic cylinders actuated by remote control by four-way valves mounted on the jibs in a location convenient for the operators.

Also, there are three hydraulic jacks operated independently for leveling the unit. Two jacks are mounted in the front of the unit and a third is mounted in the rear on the center line of the chassis. These jacks have a stroke of 2 ft.

The hydraulic tank, pump, and motor comprise a compact assembly mounted on the floor of the chassis located near the rear. The oil flows by gravity to the pump which is bolted to the bottom of the tank. The pump is connected directly with a small piston-type air motor of Scotch-yoke design. A ¾-in. air line is piped to the air motor from a tee in the 1¼-in. line running through the frame of the unit. With constant main-line pressure on the air motor, the hydraulic pump is actuated until a hydraulic pressure of approximately 1,700 lbs. is reached, at which point the air motor stalls. When any of the hydraulic lines are used and the pressure drops, the air motor automatically starts and runs until it reaches the stall point. Only 1,400-lb. pressure is needed to lift the jibs, which provides for an ample reserve in the stall point of the motor. None of the hydraulic cylinders require lock nuts to secure their positions. When the valve in the hydraulic line is closed,



HB LOCATIONS. An angle of 110 degrees between the feed and the jib is maintained for all drill holes. The holes in each group are bottomed with the same drill, the depth being automatically set by the swing of the jib.

the piston maintains that position without slippage.

Model LW6-A feeds with LM-67 drills, 2⅝-in. bore, are mounted on the jibs. The feeds have a travel of 8 ft to allow for varying conditions that may be encountered in the use of a 7-ft. drill change.

Drill-Hole Alignment

In drilling a round of holes designed for this jumbo, the chain feeds maintain an angle of 110 degrees with the jib throughout the round. The trunnions and saddles on which the feeds sit are marked at the factory for this 110-degree setting. Markers are also put on the jib swing cylinders at the factory for the alignment of the holes in a round. This eliminates all guess work on the part of the operators as to where the holes should be placed and greatly increases drilling efficiency, with fewer misbreaks because of poor hole alignment.

The jumbo fits all of the requirements demanded of it in this southeast Missouri district. Although designed primarily for drilling the burn-wedge cut round, the various adjustments allow great flexibility in drilling all types of slab settings, bottom, or roof. It has been used to blast considerable thicknesses of roof by operating from the top of the pile of broken ore and, in many cases, has been used advantageously in roof bolting. The maximum height of face that can be carried with this jumbo is 15 ft. If a higher face is carried, the top holes must be pitched upward, which results in an uneven and, oftentimes, loose roof. This means that there are many places where the Joy Drillmobile is not practical, but it is adaptable to the majority of conditions.

In a jumbo heading, a typical cycle of operations starts with the trimming down of loose rock from the roof and face by the two jumbo operators. The center line of the face to be drilled is

marked, the jumbo is moved into the heading, placed on the center line, and is leveled by means of the hydraulic jacks. The valve on the horizontal swing cylinder is opened and the jib is swung back until the indicator points to the mark for the cut holes. The feed is leveled by loosening a chuck nut and tilting by hand. The center cut hole is then drilled. By opening the valve on the vertical swing cylinder, the machine is raised 6 in. and the top cut hole is drilled by a similar operation. Using the horizontal swing cylinder, the jib is swung back until the indicator points to the mark for the first setting of slab holes and the center slab hole is drilled. In the second setting, the center slab hole is drilled in the same manner. The jib is then elevated and the top relief hole in each slab setting is drilled. Further elevation of the jib lines up the machine for drilling the top center and the slab holes. However, in order to line up with the holes already drilled, the jib must be extended by means of the rack-and-pinion arrangement. When these holes are drilled, the jib is lowered and the bottom relief, bottom center, and bottom slab holes are drilled. This completes the drilling operation.

By drilling the holes in the order outlined above, the number of adjustments to the jumbo are kept at a minimum. The leveling jacks are lifted and the jumbo is backed out of the heading. The dynamite and detonators are obtained from a nearby explosives magazine, the round is loaded, and the cap wires are connected. The plunger on the blasting machine is pushed down hard and the blast is fired. In due course, the operators go to wait for the passenger train to transport them to the shaft.

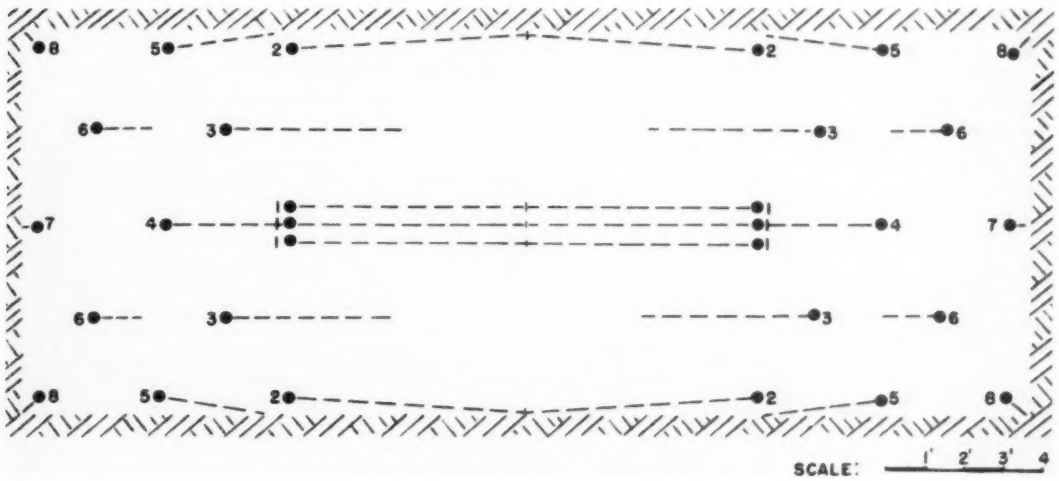
In addition to their regular daily wage, the drillers are paid an incentive bonus based on the tonnage broken. The bonus price per ton varies according to the height of ground being mined. Allowances are made for unusual conditions such as loose roof.

Better Results, Better Morale

In southeast Missouri, the jumbo has been received with a definite lack of enthusiasm on the part of some operators because of the higher consumption of explosives per ton as compared with the consumption when column-mounted drills are employed. However, this complaint assumes less significance when the advantages resulting from the use of the jumbo are considered. The physical effort exerted by the drill crew on the jumbo is considerably less than that exerted by column drillers. This makes the jumbo popular with the men and results in fewer strained backs and mashed fingers. The present shortage of skilled workmen has emphasized the advantages of the short training period required for jumbo drillers. The set drill pattern, with indicators on the jumbo for hole alignment, reduces the training period for new operators to a fraction of the time required for column drillers. The use of the jumbo has resulted in better teamwork between the day and night shifts and a smoother running organization with fewer complaints. Most important, of course, is the 13.8 per cent increase in drilling efficiency.

In reviewing the experiences of St. Joseph Lead Company, selectivity in the mining of the ore has had much to do with the favorable results. The column-mounted machine with slab drilling is based on selectivity. The driller can see the ore in the face of each setting. The jumbo, with two or more machines mounted on it, is based on tonnage and the increased efficiency of each workman. The degree to which these two ideas can be combined determines the savings in this district.

The potential of the present jumbo is considered to be 10 tons a man-shift per foot of height. This has been achieved, even bettered in several individual stopes. However, as a whole, the company has fallen short of this potential by about 25 per cent. This fact presents a challenge to the St. Joseph Lead Company operators that will, in time, lead to a better jumbo and better jumbo drilling technique.



TYPICAL ROUND: The small black circles represent the location of holes in a typical round drilled from the jumbo. The broken lines indicate the direction of the holes. The numbers alongside the holes show the order of firing a blast.

THE COLUMBIA BASIN PROJECT

Map showing location of the principal features of the Columbia Basin Project. United States Department of the Interior, Bureau of Reclamation, Columbia Basin Project, Ephrata, Washington.

The overall cost of the mammoth construction job being pushed to completion in Washington's Big Bend country is estimated at $702,500,000

CHARLES F. THOMAS*

The Big Bend country in Washington, embracing an area of more than 150 square miles in the southeastern quarter of the state, is circled on the north, west, and south by the sweeping arm of the Columbia River. The uplands are covered with rich, wheat-producing farms, often broken by channeled scablands and pockmarked with potholes belched up when molten lava flowed over the earth. Innumerable coulees, hundreds of feet deep, have been gouged through basalt by raging torrents that resulted from the melting of the Cordilleran icecap which once covered the northwestern part of the American continent. The coulees, many with beautiful lakes at the bottoms, provide wonderful panoramas in an otherwise unattractive region.

Spreading southward into the lower half of Big Ben's vast expanse, these rivers deposited their

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Ephrata, Washington

silt in the Columbia Basin, the area now being made ready for irrigation. This desert land, comprising 2,500,000 acres, is a wide alluvial plain with many moraines and basaltic upthrusts. Traders and trappers traveled the region for many years after Lewis and Clark first noted its barrenness on their famous sight-seeing trip in 1805. A few adventurous cattlemen grazed herds over the sparsely grassed desert. With the coming of railroads to the Pacific Coast, opportunities for homesteads induced many Easterners to try their luck at western farming. Some ineffectual attempts were made to construct what proved to be equally ineffectual irrigating systems.

Land of Heartbreaks

For more than fifty years, the Big Bend country has been a land of hopes and heartbreaks. Occasional streams trickling from broken escarpments, or water left in potholes after spring runoffs or the too few rains, were often fouled by alkali. Trees have been scarce in the Basin—the annual rainfall averages from 6 to 9 in. The pioneers battled heat, wind, and dust in the summers and struggled through blizzards and drifting snow in the winters. Many deserted houses, broken shacks, and the rotting remains of windmills, barns, and corrals lay as mute, fallen monuments of the ambitions of hardy men and women.

Today the scene is changed. Water is coming this year to the land because of the greatest reclamation program ever undertaken in the United States. The Columbia Basin Project, now being pushed to completion by the Bureau of Reclamation, dwarfs the imagination. For years it has been overshadowed by the immensity of the Grand Coulee Dam, across the Columbia River. As the most important unit in the vast project now under construction, Grand Coulee Dam heads a long list of other great engineering feats and construction jobs.

Behind the glory of accomplishment are the long years of planning, investigating, surveying, mapping, computing, and reporting. Many plans and routes were proposed. There were as many groups of ardent supporters or bitter critics as there were systems proposed. Investigating committees sought

GRAND COULEE DAM: This huge structure heads a long list of great feats of engineering and construction skills on the Columbia Basin Project.

FRENCHMAN HILLS TUNNEL: Fast-moving crews are driving 9,300 ft. of 16-ft.-diameter tunnel at a location 39 miles down the West Canal.

HEAVY EQUIPMENT. The construction of O'Sullivan Dam, 3½ miles long and 222 ft. high, containing a mass volume of 9,200,000 cu. yds. of material, called for the employment of diversified heavy equipment.

detailed information on every subject related to the physical, political, and economic development of the area.

From the date the present plan was approved and the big project was given the "go-ahead" order, construction has followed a rigid, almost clocklike, schedule. Much of the construction work, with schedules set years before its start, has been finished ahead of estimated completion dates.

Work on the big pumphouse, an integral part of the dam and powerhouse, followed rapidly after completion of the dam. Settings are provided for twelve centrifugal pumps, each driven by 65,000-hp. motors. In line with all the other superlatives that are justifiably used in describing the Columbia Basin Project, these pumps are the largest in the world. At present, two are in place and have been tested. A third is nearly ready and a fourth will be in place late this year. Each pump will push 720,000 gals. of water a minute through several hundred feet of tunnels and pipe lines 12 ft. in diameter, located 282 ft. up a hill above the level of Lake Roosevelt. One pump can cover 2 acres of level land with water 1 ft. deep in less than one minute. In 24 hours, one pump can discharge more than one billion gallons of water into the feeder canal.

The feeder canal, approximately 2 miles in length from the discharge openings of the pumps, has a capacity of 16,000 cu. ft. of water a second. Water, on its long flow to the first arid lands to be irrigated more than 50 miles away, is emptied into the Grand Coulee Equalizing Reservoir.

O'SULLIVAN DAM. An aerial view of the north end of O'Sullivan Dam, the largest of four earth-fill dams on the project. The area in the background will be inundated by the waters of Potholes Reservoir.

A Natural Reservoir

Because of the geographic location of the Columbia River's watershed, it is a late-season high-water stream. Lake Roosevelt, the 150-mile-long reservoir behind the dam, provides little reserve for early irrigation needs. The major portion of water required must be pumped and stored from early summer through to autumn. At that time, the river flow is seasonally reduced and its flow used for power development and down-river needs. By a strange paradox, nature created an unequalled off-river reservoir site many centuries ago when the Columbia River, obstructed by a great glacial dam, rampaged southward in a short cut, ripped the tablelands apart, and eroded the 60-mile-long Grand Coulee. This natural reservoir site, in the upper half of the Coulee, has been utilized by engineers for necessary water storage on the project. The Basin varies from 1 to 5 miles in width. Two earth-fill dams, 27 miles apart, are required to retain the water discharged into it. Already an expansive lake, developed from test pumping last autumn, it stretches from dam to dam. However, it covers only a small part of the ultimate 27,000 acres of lake area. The reservoir will contain 1,484,000 acre ft. of water with 700,000 active acre ft. The North Dam, near the town of Grand Coulee, is 145 ft. high and 1,400 ft. long. The South Dam is 10,000 ft. in length and rises 80 ft. above bedrock. More than 1,500,000 cu. yds. of material are in its embankment.

Through the head gates located in the eastern end of the South Dam at Coulee City, water enters a canyonlike section of the Main Canal, nearly 2 miles in length. The canal, excavated through solid basalt stratum to a maximum depth of more than 90 ft., has a capacity of 13,200 cu. ft. of water a second.

Bacon Coulee, 2 miles south of Coulee City, is crossed with a reinforced-concrete siphon, 1,000 ft. in length and 23 ft. in diameter. It empties into Bacon Tunnel, a 10,000-ft. bore with a lined diameter of 23 ft. 3 in. These two units of the Main Canal have a carrying capacity of 6,600 cu. ft. a second. To maintain the maximum capacity of the canal, plans provide

MAIN CANAL: The Main Canal extends crookedly in a southwesterly direction for 6½ miles. The first section had to be blasted and excavated to a depth of 90 ft. through solid basalt.

CONCRETE LINING: A look at a concrete-lined section of the Main Canal and some of the giant equipment employed. Approximately 1,000 ft. of lining operations were completed daily.

SOAP LAKE SIPHON: Steel-lined reinforced-concrete pipe with an inside diameter up to 25 ft. and walls 2 ft. thick was installed in the Soap Lake Siphon on the West Canal.

for the future construction of a similar siphon and another tunnel paralleling those already completed. All other units have been constructed, providing for all maximum needs.

Bacon Tunnel

Bacon Tunnel was driven approximately 27 ft. in diameter. The massive columnar basalt encountered through 6,500 ft. of its length developed much overbreak, despite the fact that the rock was easily drilled and blasted. More than 3,000 ft. of the bore were driven through soft sandstone. Many tree fossils were found at contact zones of basalt and sandstone. Steel support was required for about 10 per cent of the tunnel length, with no serious problems involved. Work on both headings was started with 12 ft. by 12-ft. pioneer headings. This was changed to full-face operations before the headings were holed through.

Many miles of costly canal excavation have been eliminated in utilizing natural channels for canals. The first economy effected was in the Grand Coulee Equalizing Reservoir which serves a double purpose in providing storage and 26 miles of waterway. A few hundred feet south of Bacon Tunnel, water is diverted down Trail Lake Coulee, following an old watercourse that had not been wet by Columbia River water for thousands of years. The diverted water tumbles over ragged cliffs and refills deep pools which have been empty for centuries. At various locations it is picked up in man-made channels and again released until it finally pours over 165-ft.-high cliffs near the head of Long Lake Coulee in a roaring waterfall.

Plans of the Bureau of Reclamation provide for the future construction of the East High Canal, starting eastward a short distance above the head of the falls. This canal, 110 miles long, with a capacity of 3,100 cu. ft. a second, will supply water to 205,000 acres of fertile upper land now devoted to successful wheat raising. With a plant generating energy from the waterfall, economic power would be available for pumping water to lands above the canal. No construction work is planned on this section in the near future.

Long Lake, 5½ miles long, is formed by the construction of an earth-fill dam 135 ft. high and 1,900 ft. in length. It is not a storage reservoir, but, like Grand Coulee Equalizing Reservoir, it provides a channel as well as a natural lift of water 111 ft. high to the normal lake level at the intake of the south section of the Main Canal. At this point, water will have flowed approximately 43 miles from the pumps in less than 9 miles of artificial channels.

At the western end of the dam, leading out of Long Lake, the Main Canal crawls crookedly in a southwesterly direction for 6½ miles through a concrete-lined section to the Bifurcation Works. At that point the water is divided for distribution through the East Low and West Canals to more than 1,000 miles of lateral canals and ditches which reach into all the wide expanses of the Columbia Basin. East Low Canal will be 130 miles long and will supply water to 252,000 acres. It is designed to carry 4,500 cu. ft. of water a second. West Canal will be 88 miles in length and, with a capacity of 5,100 cu. ft. a second, will furnish water to 281,000 acres. The laterals, ranging from good-sized canals to small ditches, are balanced according to the

acreage each must supply. Head gates and weirs control and divide the water allocated to each farm. Precast concrete pipe, ranging from 12 to 60 in. in diameter, has been used in the siphons in the construction of all the laterals. Wherever good land lies above the laterals, pumps have been installed to lift water to higher levels.

Synchronized Concrete Lining

Wherever concrete lining was required in the larger canals, all contractors on the project followed a uniform method of operation. Following the completion of the blasting and rough excavation details, selected backfill material was spread on the slopes and bottoms of the canals. This material was thoroughly wet and compacted prior to fine grading. It was kept damp until concrete was placed. Huge gantry frames, spanning the canal and supported by wheeled trucks rolling on single-rail tracks on each bank, rapidly performed the normally tedious work of fine grading. Moving blades whittled the high spots and dragged excess material to the canal bottom, where it was picked up by conveyor buckets and dumped outside the canal embankment. The concrete-placing equipment, mounted on a gantry similar to the fine-grading outfit, followed closely on the wheels of the grader. Fast-moving skips, charged from a concrete hopper centrally placed on the deck of the giant traveler, dropped their loads into numerous chutes spaced across the framework, from where they were deposited evenly over the canal surface. Moving screeds struck off the concrete to grade as the gantry rolled along the winding canal banks faster than 2 ft. a minute. Nearly all operations were handled mechanically, which reduced manual labor needs to a minimum. Two large concrete paving mixers operating in tandem were used on most of the work. They were moved along the embankment roadway as the placing advanced, discharging their mixed batches on a belt conveyor feeding the central hopper. Slipscreeds mounted on the big, awkward-appearing machine gave the concrete the initial floating. Half a dozen finishers, riding on a carriage tied a few feet behind the placing machine, cut joints, filled them with compound, and gave the concrete surfaces the finishing touches. Another carriage tagged along a hundred feet to the rear, from which two workmen sprayed white curing compound over the project. Large fleets of trucks, hauling from central batching plants, supplied the mixers with dry batched concrete. More than 45 miles of the large canals have been lined with concrete. They have also been fenced with barbed wire to prevent livestock or wild game from tumbling into the canals, and to discourage dangerous swimming. Ladder steps on the slopes of the canals have been embedded in the concrete at regular intervals.

Work on the Soap Lake Siphon on the West Canal was one of the spectacular jobs of the project. Constructed by Winston Brothers & Utah Construction Company at a cost of $7,700,000, it attracted much attention because of the complex type of work involved. Seven subcontractors, each a specialist in his line of work, participated in the construction. A highly coordinated program involving the drilling and blasting of basalt and caliche; excavating; bending, welding, and placing of reinforcing steel; fabricating and setting steel liner tubes; moving forms; and the placing and curing of concrete was carried on. The job was finished many months ahead of the completion date specified in the contract.

Soap Lake Siphon

Soap Lake Siphon was designed originally to cross under Soap Lake, a much advertised body of water said to possess wonderful curative qualities for arthritis, rheumatism, and skin diseases. To avoid conflicts with property owners in the town of Soap Lake, located on the south shore of the lake, the siphon was rerouted to skirt the north end of the lake. Starting high on a hill 2 miles northeast of the town, the siphon drops down into the lower end of Grand Coulee, follows along the north shore of the lake, and rises again to the west escarpment of the Coulee, forming a huge semicircle 12,836 ft. long. It consists of 8,250 ft. of steel-lined reinforced-concrete pipe with an inside diameter of 22 ft. 4 in. and a wall thickness of 21 in., and 4,586 ft. of monolithic reinforced-concrete pipe 25 ft. in diameter, with a thickness of 24 in. The steel-lined portion is in the central and lower part of the siphon where the hydrostatic head ranges from 100 ft. to 225 ft. The parts of the siphon at the upper and lower ends were constructed in sections 25 ft. long, with asphalt-coated-steel water stops 10 in. wide embedded at each joint. Joints in the steel-lined section were welded throughout its length. Because of the combination of both horizontal and vertical curves, extreme precision was required in the design and fabrication of the sections of steel tube in the structure. Water flows through the siphon at a rate of 13 ft. a second.

Two additional siphons having a combined length of 5,500 ft. were built on the West Canal. By the end of the year nine siphons with a total length of 24,893 ft. will have been constructed on the East Low Canal. East Low siphons vary from 19 ft. 4 in. to 14 ft. 8 in. in diameter.

O'Sullivan Dam

O'Sullivan Dam, located in the central part of the Columbia Basin, is the largest of the four earth-fill dams on the project. It is the fourth longest dam in the United States. The structure, 3½ miles long and 222 ft. high, has a mass volume of 9,200,000 cu. yds. It was constructed by Lytle, Amis & Green, of Sioux City, Iowa, at a cost of $10,500,000. The dam was named after the late James O'Sullivan, an energetic booster for irrigation in the region. It cuts off Crab Creek and other minor drainage channels near the eastern end of Frenchman Hills and will increase Potholes Reservoir to a lake covering 46 square miles. It will be linked with Moses Lake, the largest single body of water currently in the area. In addition to the accumulation of natural runoff, waste irrigation water will be picked up. Its supply can be augmented with water from both the West and East Low Canals through wasteways emptying into the reservoir. When filled, it will supply Potholes East Canal with 3,900 cu. ft. of water a second. This canal will be 54 miles long, extending close to the town of Pasco at the extreme southern end of the Basin, and will deliver water to 254,00 acres. Another canal, the Potholes West Canal, will lead from the

FLOWING WATER. A Bureau of Reclamation engineer inspects the flow of water around a curve in a concrete-lined canal near the town of Pasco. This waterway is much smaller than the main arteries near Ephrata, Quincy, and Moses Lake.

west end of O'Sullivan Dam around the east end of Frenchman Hills. It will irrigate approximately 14,000 acres on the Royal Slope.

A tract of 5,500 acres of land northwest of Pasco was subdivided into eighty-four farms and sold to veterans of World War II in 1947 and 1948. Water, supplied to the farms by a pumping plant installed on the Columbia River, has demonstrated what can be accomplished from irrigation in the Basin. Recent economic reports for 1951 show a gross return of $138 an acre for the area. The present distribution system calls for water to be supplied from the main project as soon as construction to it has been completed.

Two major pump lifts are being built on the West Canal. The first and larger is being erected near Winchester, a small village 10 miles west of Ephrata. Six pumps will deliver 348 cu. ft. of water a second to a series of lateral canals lying along the south slope of the high range of rolling hills west and north of the towns of Ephrata and Quincy. Laterals will turn east and west in a series of lifts until, 6,000 ft. from the pumps, water will be lifted 225 ft. above the canal level. Strangely, water which has passed Ephrata in the Main Canal will be returned to within a mile of the city from the high lift lateral flowing back to the east. More than 22,000 acres of land will be included in this development. The second plant will be located 3 miles west of Quincy and will deliver water to the slopes of Babcock Ridge which lies to the west and above the West Canal.

Frenchman Hills Tunnel

Fifty-nine miles down the West Canal, the second big tunnel job on the project in under construction. Fast-moving crews are driving 9,300 ft. of 16-ft.-diameter tunnel through Frenchman Hills. The job was started in July, 1951, by the contractors, United Concrete Pipe Corporation and Ralph Bell, of Baldwin, California. The holing-through celebration is scheduled for mid-July, 1952. The tunnel is being driven through formations of broken basalt, caliche, clay, and occasional semisolid formations of basalt. To date, approximately 85 per cent of the bore has been supported with steel and lagging. Daily progress has averaged 30 lin. ft. of tunnel a day. Up to 46 holes are drilled to pull an average 6-ft. round. Drilling time requires about 45 minutes; mucking out consumes 90 minutes. From 2½ to 4 lbs. of 40% strength dynamite is used per cu. yd. of rock broken. Detachable bits attached to 1¼-in. drill steel are used on the drills. The all-steel drill jumbo, mounting from five to seven machines, is combined with a "cherry picker," or car changer. It has an outside track gauge of 8 ft. 10 in. and allows for passage between the supports of motors and cars on a standard 36-in. gauge tunnel track. A hydraulically operated and locking arm provides for the rapid shifting and positioning of the drills and the positive locking of the machine in drilling position. Lining will be completed in 1953 and the finished tunnel will be 14 ft. in diameter. Both the Frenchman Hills and the Bacon Tunnels are of the standard horseshoe

type. An average of eighty-six employes is used, working on a three-shift, six-day-a-week schedule.

On a job such as the Columbia Basin Project, the engineering and construction work are the most spectacular features. The serious part of the program starts when the operations and maintenance departments of the Bureau take over and begin the responsible task of delivering water to the farms. Various details of this work have been under study for several years and a carefully prepared plan has been adopted. Accommodations for watermasters, pumpmen, ditchriders, and numerous other employes have been established at many locations over the Basin area. Homes for gatetenders have been erected at dams or near wastegates that have been placed at strategic points along the big canals. Shops have been built and equipped to repair trucks, cars, and other mechanical units used in maintenance work. Ditchriders patrol their units in a pickup automobile equipped with a shovel, a fork, and a radio. If a leak occurs, a ditchrider can communicate with his watermaster or gatetender in a few seconds. If additional help is needed, he can have it quickly. Ditchriders are always on guard to prevent trouble, or to repair any damage that may occur. Such crews are being assembled and some are on the job. The organization will continually increase as the water becomes available for more and more acres of land each year.

In 1952, laterals will be ready to supply water to more than 80,000 acres of land in the northern part of the Basin. Most of the machinery used in the construction of this great canal system has been moved south on the project or has been dismantled and shipped away. But dozens of tractors, bulldozers, and carryalls are busily engaged in leveling land in numerous areas preparatory to the planting of crops. Many ranchers will use modern sprinkling systems to spray water on their fields and crops. Some sprinkling systems require dismantling and the relaying of pipe for each area where irrigation is required. Other experimental work has been done successfully with aluminum pipe suspended at intervals through the hubs of wheels which are rolled across the fields as sprinkling is needed. Water is pumped into such lines and the pressure developed forces the water over wide areas surrounding each sprinkler head.

"Here Comes the Water"

Much of the acreage in the Basin is privately owned but land held by the government is being made available first to war veterans. Several drawings for government lands have been held and have attracted national attention. Some of the rules relating to the acquisition of such land are rather rigid but they are eased as much as possible for the veterans who can qualify.

In the late autumn of 1951, canals and many of the laterals in the northern section of the Basin were tested with water as soon as the contractors and their equipment were out of the way. Each day, crowds watched the water creep along the new canal channels. Men, women, and children walked for miles ahead of the water. Many cried with joy and happiness as they saw water coming to their arid lands. Pessimists, critics, and doubters of the abilities of the Bureau of Reclamation engineers to plan and complete such an undertaking, joined in the united acclaim, "They did it after all. Here comes the water."

To celebrate the delivery of water to the first of the 1,029,000 acres of land to be brought under irrigation, the last ten days in May, 1952, have been set aside for a widespread program of pageantry, fairs, entertainment, and thanksgiving. The town of Pasco, far down on the southern edge of the Basin, will start the celebration with a four-day program, to be followed by a pageant at Soap Lake and a three-day fair at Ephrata. Ephrata, the city second in size in the Columbia Basin, is the district headquarters for the project. Here the Bureau of Reclamation is housed in a large three-story office building from which the engineering and business affairs of the system are administered.

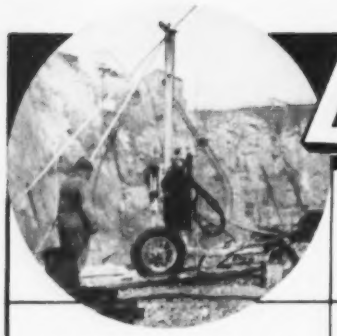
Moses Lake, another thriving town 20 miles east of Ephrata, will stage a unique feature in developing an 80-acre farm in a single day. This will include the construction of a modern three-bedroom home and a barn. The farm will be equipped with machinery and livestock and will be presented to a man selected as the most worthy veteran of World War II or Korea. Veteran groups throughout the United States are aiding in the selection of this winner. Another of the popular drawings for government land will be held in Othello on May 31, when governors of various states are expected to be present and participate in the program. The celebration will close June 1 with a great interdenominational church service to be held on the shore of Soap Lake. The Washington and Northern Idaho Councils of Churches are cooperating in the service. A theme of thankfulness for the coming of the water will be stressed.

Total cost of the Columbia Basin Project is estimated at $702,500,000. Of this amount, approximately $483,500,000 represents costs attributable to the irrigation of 1,029,000 acres. The balance is divided as follows: commercial power, $158,000,000; downstream river regulation, $40,000,000; navigation, $1,000,000; self-liquidating programs, such as land purchased, $20,000,000.

Commercial power sales are expected to repay more than 75 per cent of the total construction cost of the project. The balance will be repaid to the U. S. Treasury by the settlers. This will make the Columbia Basin Project a self-supporting enterprise, which, in turn, will contribute millions of dollars to the national prosperity in the form of crops and other benefits.

Fertile Fields

Visitors to the Columbia Basin during the next few months, and for years to come, will see the development of a vast new empire in the northwest. They will find hundreds of homes being constructed and dozens of well-drill rigs drilling deep holes through the underlying basalt for domestic water supply. Fertile land with rich, growing crops will have supplanted the sagebrush, thistles, and cheat grass growing there only a few months ago. They will see what has been, for many centuries, a barren, lonesome desert, transformed into useful, productive fields. There is yet a hard struggle ahead. The job is not done. Tough though the going may be for all concerned, the odds will be in their favor because "Here Comes the Water!"



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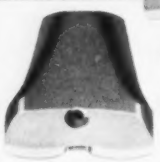

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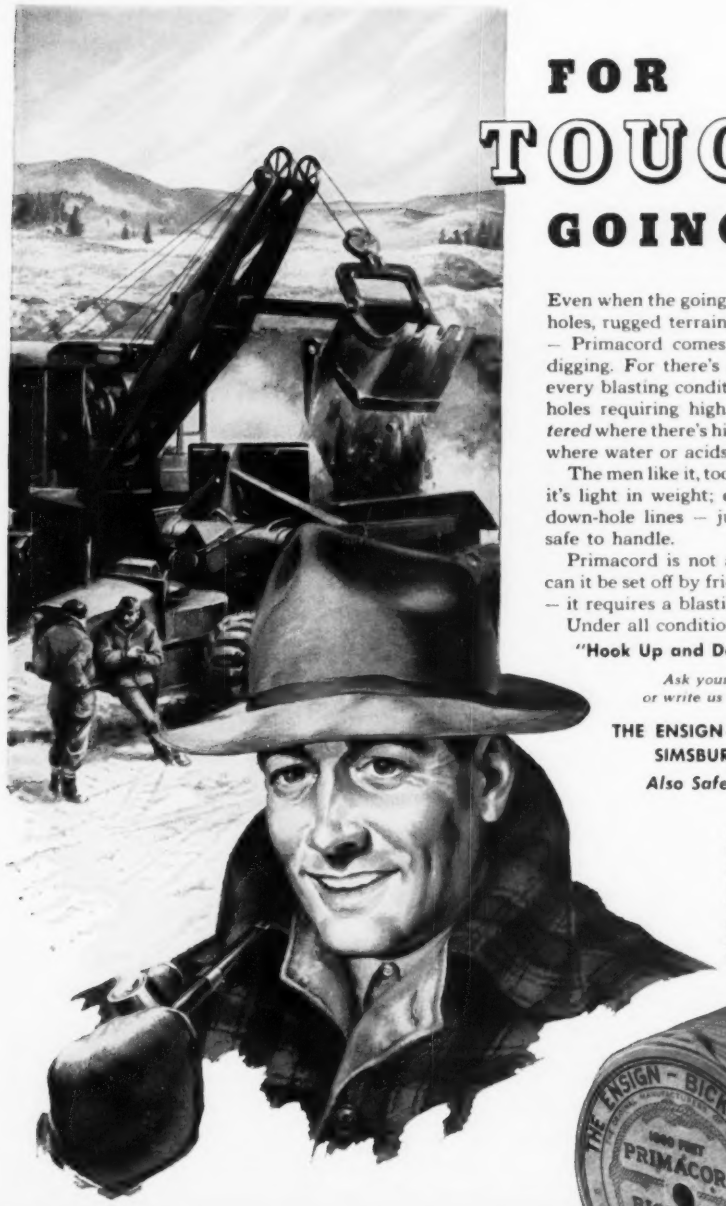

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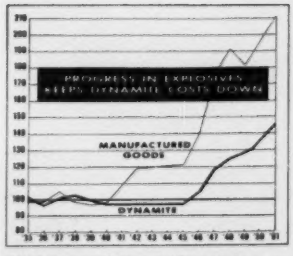

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